IS 6162-1 (1971): Paper-Covered Aluminium Conductors, Part I: Round Conductors [ETD 33: Winding Wire]

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(Reaffirmed 1993)

Indian Standard

SPECIFICATION FOR PAPER-COVERED ALUMINIUM CONDUCTORS

PART I ROUND CONDUCTORS

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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TO
IS 6162 (Part 1) : 1971 SPECIFICATION FOR PAPER- COVERED ALUMINIUM CONDUCTORS
PART 1 ROUND CONDUCTORS

(*Page* 12, *clause* 8) — Delete and renumber the rest.

(*Page* 20, *Appendix* F) — Delete.

(ETD 33)

Reprography Unit, BIS, New Delhi, India

(Reaffirmed 1993)

Indian Standard

SPECIFICATION FOR PAPER-COVERED ALUMINIUM CONDUCTORS

PART I ROUND CONDUCTORS

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Indian Standard

SPECIFICATION FOR PAPER-COVERED ALUMINIUM CONDUCTORS

PART I ROUND CONDUCTORS

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 14 June 1971, after the draft finalized by the Winding Wires Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard has been formulated in view of the increasing use of aluminium as electrical conductor for windings of electrical machines, such as transformers.

0.3 In the preparation of this standard, assistance has been derived from the following publications:

IEC Publication 111 (1959) Recommendations for the resistivity of commercial hard-drawn aluminium electrical conductor wire. International Electrotechnical Commission.

IEC Publication 121 (1960) Recommendations for commercial annealed aluminium electrical conductor wire. International Electrotechnical Commission.

BS 2627 : 1961 Specification for wrought aluminium for electrical purposes wire (other than that used for overhead conductors). British Standards Institution.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 General — This standard (Part I) gives requirements and tests for round aluminium conductors, covered with two or more layers of paper, primarily intended for transformer windings.

*Rules for rounding off numerical values (*revised*).

1.2 Sizes — The requirements of this standard are applicable to conductors having diameters 0·500 to 5·000 mm, both inclusive.

1.3 Grades of Covering — Three grades of covering are specified:

a) Double paper covering, Ordinary (O);

b) Double paper covering, Fine (F); and

c) Multiple paper covering, Special (S).

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Wire — The insulated material as received.

2.2 Conductor — The bare metal after removal of the paper covering.

2.3 Increase in Diameter Due to Covering — The difference between the diameter over the paper covering and the diameter of the conductor.

2.4 Tolerance — The permissible divergence of an actual magnitude from that prescribed.

2.5 Overlap Wound — Paper tape wound with each turn overlapping the preceding turn by not less than 25 percent of the paper width.

3. GENERAL TEST CONDITIONS

3.1 Unless otherwise specified, all tests shall be carried out within a temperature range of 15 to 35°C, and at a relative humidity range of 45 to 75 percent. Before measurements are made, the specimens shall be preconditioned under these atmospheric conditions for a time sufficient to allow specimens to reach stability.

3.2 The wire to be tested shall be removed from the packaging in such a way that the wire will not be subjected to tension or unnecessary bends.

3.3 Before each test sufficient wire shall be discarded to ensure that any damaged wire is not included in the test specimens.

3.4 When no specific range of sizes is given for a test, the test is applicable to all sizes.

4. CONDUCTOR

4.1 Material — The conductor shall be manufactured from EC grade aluminium ingots conforming to any of the two grades specified in

IS : 4026-1969*, and shall be in one of the following conditions:

Annealed	O
Three-quarter hard	H3†
Hard	H4†

4.1.1 *Physical Constants for Aluminium*

4.1.1.1 *Resistance* — The resistance at 20°C of an aluminium conductor 1 m in length and of a uniform cross-sectional area 1 mm^2 shall be taken as follows:

Condition	*Resistivity* ohm·mm^2/m
O	0·028 0
H3	0·028 264
H4	0·028 264

4.1.1.2 *Density* — The density at 20°C shall be taken as 2·703 g/cm^3.

4.1.1.3 *Coefficient of linear expansion* — The coefficient of linear expansion at 20°C shall be taken as 23×10^{-6} per deg Celsius.

4.1.1.4 *'Constant mass' temperature coefficient of resistance* — The constant mass temperature coefficient of resistance at 20°C measured between two potential points rigidly fixed to the conductor, shall be taken as 0·004 per deg Celsius.

NOTE — For any temperature t_0 above 0°C, the temperature coefficient of resistance is $\frac{1}{230 + t_0}$.

4.2 Diameter

4.2.1 The diameters and tolerance on conductor diameters shall be as given in Table 1.

NOTE — The conductors shall be checked for diameter and/or resistance in the following manner:

Diameter mm	*Measurement*
Up to and including 1·000	By resistance and diameter
Over 1·000	Only by diameter

4.3 Resistance — (*see* Note under 4.2.1)

4.3.1 The resistance of the conductors at 20°C shall be as given in Table 1.

*Specification for aluminium ingots (EC grade) (*first revision*).

†New designations H3 and H4 for the old designations 3/4H and H respectively (*see* IS : 5052-1969 Temper designations of aluminium and its alloys).

TABLE 1 DIAMETERS AND RESISTANCES OF PAPER COVERED ROUND ALUMINIUM CONDUCTORS

(*Clauses* 4.2.1, 4.3.1, 4.3.2 *and* 7.1)

Nominal Conductor Diameter	Tolerance	Ordinary Covering (O)		Fine Covering (F)		Resistance at 20°C for Condition					
		Overall Dia	Increase in Dia	Overall Dia	Increase in Dia	O			H3 and H4		
		Max	*Min*	*Max*	*Min*	*Nominal*	*Max*	*Min*	*Nominal*	*Max*	*Min*
mm	±t mm	mm	mm	mm	mm	Ω/m	Ω/m	Ω/m	Ω/m	Ω/m	Ω/m
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
0·500	0·005	0·755	0·200	0·680	0·150	0·142 6	0·146 5	0·138 8	0·143 9	0·148 1	0·139 9
0·560	0·006	0·815	0·200	0·740	0·150	0·113 7	0·117 0	0·110 5	0·114 8	0·118 3	0·113 9
0·630	0·006	0·885	0·200	0·810	0·150	0·089 82	0·092 21	0·087 51	0·090 67	0·093 21	0·088 22
0·710	0·007	0·990	0·225	0·890	0·150	0·070 72	0·072 65	0·068 85	0·071 39	0·073 44	0·069 41
0·750	0·008	1·035	0·225	0·935	0·150	0·063 38	0·065 22	0·061 60	0·063 98	0·065 92	0·062 11
0·800	0·008	1·085	0·225	0·985	0·150	0·055 70	0·057 24	0·054 22	0·056 23	0·057 86	0·054 66
0·850	0·009	1·135	0·225	1·035	0·150	0·049 34	0·050 77	0·047 97	0·049 81	0·051 32	0·048 16
0·900	0·009	1·185	0·225	1·085	0·150	0·044 01	0·045 23	0·042 84	0·044 43	0·045 72	0·043 19
0·950	0·010	1·235	0·225	1·135	0·150	0·039 50	0·040 64	0·038 41	0·039 87	0·041 08	0·038 72
1·000	0·010	1·285	0·225	1·210	0·175	0·035 65	0·036 63	0·034 70	0·035 99	0·037 03	0·034 98
1·060	0·011	1·345	0·225	1·270	0·175	0·031 73	—	—	0·032 03	—	—
1·120	0·011	1·405	0·225	1·330	0·175	0·028 42	—	—	0·028 69	—	—
1·180	0·012	1·465	0·225	1·390	0·175	0·025 60	—	—	0·025 85	—	—
1·250	0·013	1·540	0·225	1·465	0·175	0·022 82	—	—	0·023 03	—	—
1·320	0·013	1·610	0·225	1·535	0·175	0·020 46	—	—	0·020 65	—	—
1·400	0·014	1·715	0·250	1·640	0·200	0·018 19	—	—	0·018 36	—	—

1·500	0·015	1·815	0·250	1·740	0·200	0·015 84	—	—	0·015 99	—	—
1·600	0·016	1·915	0·250	1·840	0·200	0·013 93	—	—	0·014 06	—	—
1·700	0·017	2·015	0·250	1·940	0·200	0·012 34	—	—	0·012 45	—	—
1·800	0·018	2·120	0·250	2·045	0·200	0·011 00	—	—	0·011 11	—	—
1·900	0·019	2·220	0·250	2·145	0·200	0·009 876	—	—	0·009 969	—	—
2·000	0·020	2·370	0·300	2·270	0·225	0·008 913	—	—	0·008 997	—	—
2·120	0·021	2·490	0·300	2·390	0·225	0·007 932	—	—	0·008 007	—	—
2·240	0·022	2·610	0·300	2·510	0·225	0·007 105	—	—	0·007 172	—	—
2·360	0·024	2·735	0·300	2·635	0·225	0·006 401	—	—	0·006 461	—	—
2·500	0·025	2·875	0·300	2·775	0·225	0·005 704	—	—	0·005 758	—	—
2·650	0·027	3·025	0·300	2·930	0·225	0·005 077	—	—	0·005 124	—	—
2·800	0·028	3·180	0·300	3·080	0·225	0·004 547	—	—	0·004 590	—	—
3·000	0·030	3·380	0·300	3·280	0·225	0·003 961	—	—	0·003 998	—	—
3·150	0·032	3·530	0·300	3·430	0·225	0·003 593	—	—	0·003 626	—	—
3·350	0·034	3·735	0·300	3·635	0·225	0·003 177	—	—	0·003 206	—	—
3·550	0·036	3·935	0·300	3·835	0·225	0·002 829	—	—	0·002 855	—	—
3·750	0·038	4·140	0·300	4·040	0·225	0·002 535	—	—	0·002 559	—	—
4·000	0·040	4·390	0·300	4·315	0·225	0·002 228	—	—	0·002 249	—	—
4·250	0·043	4·645	0·300	4·570	0·225	0·001 974	—	—	0·001 992	—	—
4·500	0·045	4·895	0·300	4·820	0·225	0·001 761	—	—	0·001 777	—	—
4·750	0·048	5·150	0·300	5·075	0·225	0·001 580	—	—	0·001 595	—	—
5·000	0·050	5·400	0·300	5·325	0·225	0·001 426	—	—	0·001 439	—	—

4.3.1.1 The resistance of the conductor shall be expressed as the dc resistance at 20°C. The method used shall provide an accuracy of 0·5 percent.

One measurement shall be made.

If the resistance R_t is measured at a temperature t other than 20°C, the resistance R_{20} at 20°C, shall be calculated by means of the formula:

$$R_{20} = \frac{R_t}{1 + 0{\cdot}004\ (t - 20)}$$

where

t is the actual temperature in °C during the measurement.

4.3.2 *Tolerance on Resistance* — The maximum and minimum permissible values of resistance shall be as given in Table 1 and are calculated by the method described in Appendix A.

4.4 Tensile Strength and Elongation — A sample of conductor 250 mm long between grips shall be steadily stretched at a rate not more than 100 mm/min until the conductor fractures. The tensile strength and elongation at fracture shall comply with the requirements of Table 2.

NOTE — It is recognized that 0·2 percent proof stress values of aluminium are of importance. These values are under consideration and will be included later.

4.5 Wrapping Test — The conductor shall be wrapped round a conductor of its own diameter to form a close helix of 8 turns; 6 turns shall then be unwrapped and again closely rewrapped in the same direction as the first wrapping. The conductor shall not crack.

4.6 Joints — Unless otherwise agreed to between the purchaser and the supplier, all joints in the conductor shall be welded and subsequently cold worked. Where unworked joints are permitted by agreement, the type of joint and the marking shall be as agreed.

4.7 Freedom from Defects — The conductor shall be finished clean and smooth and shall be substantially free from slivers, spills, dust, cracks and other defects.

5. PAPER

5.1 Grade of Paper — The paper, before application, shall be free from metallic and other injurious inclusions, shall have no deleterious effect on insulating oil and shall be of such quality that it will satisfy the requirements of **5.2** to **5.8**.

5.2 Thickness — The thickness of the paper used shall *preferably* be between the limits of 0·025 and 0·075 mm, both inclusive.

TABLE 2 TENSILE STRENGTH AND ELONGATION

(*Clause* 4.4)

CONDITION	NOMINAL CONDUCTOR DIAMETER		TENSILE STRENGTH		ELONGATION, *Min* PERCENT	
	Over	Up to and including	*Min*	*Max*		
(1)	(2)	(3)	(4)	(5)	(6)	
	mm	mm	*MN/m²	*MN/m²		
O	—	5·000	69	100	15	
H3	—	5·000	125	166	—	
H4	1·300	1·500	192	—	—	
	1·500	1·800	187	—	—	
	1·800	2·000	182	—	—	
	2·000	2·300	178	—	—	
	2·300	2·500	174	—	—	
	2·500	2·800	170	—	—	(*see* 4.5)
	2·800	3·000	167	—	—	
	3·000	3·300	164	—	—	
	3·300	3·600	162	—	—	
	3·600	3·800	161	—	—	
	3·800	4·100	160	—	—	
	4·100	5·000	159	—	—	

NOTE — It is to be noted that the tensile strength values for conductor diameter over 3 mm for H4 condition are overlapping with those of H3. When discriminatory values are evolved, the same will be included.

*Meganewton.

5.2.1 The measurement of thickness shall be done in accordance with **7** of IS : 1060 (Part I)-1966*.

5.3 Tensile Strength — The tensile strength of the paper, when determined in accordance with **12.3** of IS : 1060 (Part I)-1966*, shall be not less than 55 †MN/m² in the longitudinal direction and 20 †MN/m² in the transverse direction.

5.4 Ageing (Bursting Strength) Test — The bursting strength of the paper shall be determined as described in Appendix B before and after the heat ageing treatment described in the same appendix. The decrease in the bursting strength of the paper due to the heat treatment shall not exceed 20 percent.

5.5 *p*H Value of Water Extract — The *p*H value of water extract of the paper when determined by the method described in Appendix K of IS : 1576-1967‡ shall be not less than 6·5 and not more than 8·0.

*Method of sampling and test for paper and allied products, Part I (*revised*).

†Meganewton.

‡Specification for solid pressboard for electrical purposes.

5.6 Conductivity of Water Extract — The conductivity of the water extract of the paper, when determined as described in Appendix D, shall be not greater than 22 microsiemens per centimetre.

5.7 Oil Absorption — The height to which the oil shall rise in either the longitudinal or the transverse direction of paper, when it is tested as described in Appendix E shall be between the appropriate limits given in Table 3.

TABLE 3 OIL ABSORPTION

Nominal Thickness of Paper	Height of Rise of Oil
(1)	(2)
mm	mm
0·075	35 to 65
0·065	30 ,, 60
0·050	25 ,, 55
0·038	20 ,, 50
0·025	15 ,, 45

5.8 Ageing in Oil — The tensile strength of the paper when determined in accordance with **12.3** of IS : 1060 (Part I)-1966*, before and after keeping the specimens in insulating oil, as described in **5.8.1**, shall indicate the measure for ageing. The difference between the two values shall be not more than 25 percent of the first value.

5.8.1 From the test piece, twelve test strips 250 × 15 mm shall be taken in the longitudinal direction and twelve in the transverse direction. They shall be stored in insulating oil at 105°C for 7 days.

6. APPLICATION OF PAPER

6.1 General — To prevent the inclusion of aluminium dust or other extraneous matter under the paper covering, the conductor shall be fully cleaned by felt pads or other suitable means immediately before entering the paper covering machine. Each layer of paper shall be continuous, firmly applied and substantially free from creases. No bonding or adhesive material shall be used except to anchor the ends of paper. Any such bonding or adhesive material shall have no deleterious effect on transformer oil, insulating paper or the electric strength of the covering. Where more than two layers of covering are used, the outermost layer shall be the thickest.

*Method of sampling and test for paper and allied products, Part I (*revised*).

6.2 Width of Paper — Unless otherwise agreed to between the manufacturer and the purchaser, the width of the paper used for lapping shall not exceed three times the diameter of the conductor with a maximum of 12 mm and a minimum of 3 mm.

6.3 Arrangement of Layers — According to the number of layers used, the paper shall be applied as follows:

a) *Two Layers* — When there are two layers, both of them shall be overlap wound in the opposite directions.

b) *More than Two Layers* — All the layers shall be overlap wound in the same direction.

NOTE — Layer arrangements differing from those specified in this clause may be adopted by agreement between the manufacturer and the purchaser provided that the insulated conductor meets all the other requirements of this standard.

7. OVERALL DIAMETER AND INCREASE IN DIAMETER

7.1 Double Paper Covering, Ordinary (O) and Fine (F) — The maximum overall diameter and the minimum increase in diameter due to covering shall be in accordance with Table 1.

7.2 Multiple Paper Covering, Special (S) — The overall diameter of the covered wire shall be as agreed to between the manufacturer and the purchaser; however, the increase in diameter due to covering shall not exceed that specified nor shall it be less than that specified by more than the appropriate tolerances given in Table 4.

TABLE 4 TOLERANCE ON SPECIAL COVERING

INCREASE IN DIAMETER DUE TO COVERING	TOLERANCE, PERCENT
(1)	(2)
mm	
0·25 to 0·50, inclusive	10
Over 0·5 up to and including 1·3	7·5
Over 1·3	5

7.3 Measuring Equipment — The measurement shall be made with an accuracy better than 0·002 mm. If a micrometer is used it shall be ensured that the measuring force is in the range of 0·75 to 1·25 N. The spindle and the anvil of the micrometer shall have a diameter of 5 to 8 mm.

Alternatively a force of 1 to 3 N may be used.

7.4 Measuring Method

7.4.1 *Overall Diameter of the Wire* — Approximately 1·5 m length of the wire from the reel shall be discarded and the diameter shall be determined over the paper covering. Three measurements at 60° angular displacement shall be made around the circumference of the wire at each of two places 1 m apart.

The average of the six results shall be reported as ' overall diameter '.

7.4.2 *Conductor Diameter* — The paper covering shall be removed at two places 1 m apart.

Three measurments at 60° angular displacement shall be made around the circumference of the conductor at these places.

The average of the six results for the bare diameter shall be reported as ' conductor diameter '.

7.4.3 *Increase in Diameter*— The difference between the overall diameter and the conductor diameter is the increase in diameter due to the covering.

8. PACKING AND MARKING

8.1 The wire shall be tightly and evenly wound on reels (*see* IS : 482-1968*) in such a direction that when unrolled, the exposed edge of the overlap of the outer layer of the paper is towards the drum.

8.1.1 The label which is to be securely attached to the reel, shall have the following information:

a) Manufacturer's name or trade-mark,

b) Grade of covering,

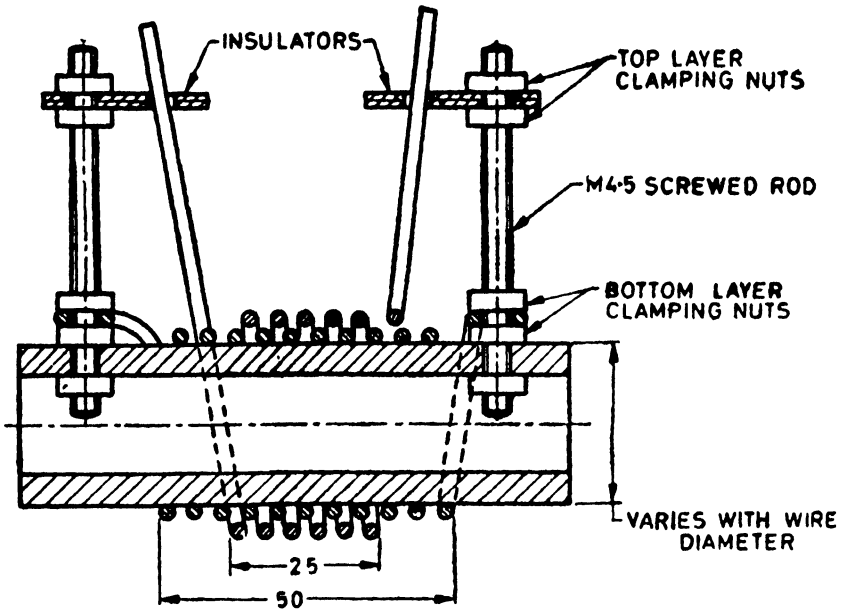
c) Nominal conductor diameter,

d) Weight of wire, and

e) Number of lengths, if there is more than one length of wire in one reel.

8.1.2 When more than one length of wire is wound on the same reel, the different lengths shall not be anchored with each other, but strips of paper having colour distinctly different from that of the paper covered conductor shall be placed between two adjacent lengths to mark the start of the next length.

*Specification for reels for covered, round electrical winding wires (*second revision*).



All dimensions in millimetres.

FIG. 1 TYPICAL SPECIMEN FOR ELECTRIC STRENGTH (PROOF) TEST

TABLE 5 TEST VOLTAGE FOR ELECTRIC STRENGTH (PROOF) TEST

(*Clause* 8.1)

SPECIFIED MINIMUM INCREASE IN DIAMETER DUE TO THE COVERING	TEST VOLTAGE FOR DOUBLE PAPER COVERING, ORDINARY (O) AND FINE (F)
(1)	(2)
mm	kV (rms)
0·150	5·5
0·175	6·5
0·200	8·0
0·225	8·5
0·250	9·0
0·300	11·0

NOTE — The test voltages for multiple paper covering, special (S) shall be as agreed to between the manufacturer and the purchaser.

8.2 The label may also be marked with the Standard Mark.

The use of the Standard Mark is governed by the provision of *Bureau of Indian Standard Act,* 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

9. SAMPLING

9.1 A recommendatory sampling plan and criteria for acceptance of lot are given in Appendix F.

9.2 **Acceptance Tests** — The following tests shall constitute acceptance tests:

a) Conductor diameter (*see* **4.2**),

b) Arrangement of layers (*see* **6.3**),

c) Overall diameter (*see* **7**), and

d) Increase in diameter (*see* **7**).

APPENDIX A

(*Clause* 4.3.2)

METHOD OF CALCULATION OF LINEAR RESISTANCE

A-1. LIMITS OF ELECTRICAL RESISTANCE

A-1.1 The limits of electrical resistance are calculated on the following basis.

A-1.1.1 The maximum and minimum values of resistance for conductors of diameter up to and including 1·000 mm are calculated from the maximum and minimum values of resistivity by taking into account for each diameter the relevant dimensional tolerance.

The linear resistance is calculated from:

$$R_{Max} = \rho_{Max} \cdot q^{-1}_{Min} \ (\Omega/m)$$

$$R_{Min} = \rho_{Min} \cdot q^{-1}_{Max} \ (\Omega/m)$$

where q_{Max} and q_{Min} are respectively the maximum and minimum conductor cross-section in millimetre square calculated by taking into account the relevant dimensional tolerance for the diameter.

A-1.1.2 The maximum and minimum values of resistivity of aluminium are given below:

Condition	*Resistivity*	
	ρ_{Max} ohm·mm²/m	ρ_{Min} ohm·mm²/m
O	0·028 2	0·027 8
H3 or H4	0·028 506	0·028 027

APPENDIX B

(*Clause* 5.4)

DETERMINATION OF AGEING BY BURSTING STRENGTH TEST

B.1. GENERAL

B-1.1 The bursting strength of the paper before and after the heat treatment is determined on samples cut from the same sheet.

B-1.2 Not fewer than 15 portions of paper, each of sufficient size to provide a pair of test specimens, are taken at random from the bulk. Each portion is halved so as to provide two sets of specimens, one of which is tested after conditioning only and the other after completion of the heat-ageing treatment described in **B-2.1** and subsequent conditioning.

B-1.3 The specimens to be conditioned only are subjected to the treatment specified in Appendix C and the bursting strength is determined in the controlled atmosphere or as soon as possible after removal from it and in any case within 3 minutes of removal.

B-2. CONDITIONING

B-2.1 The specimens to be subjected to heat-ageing treatment are heated by suspending in a suitable oven, care being taken to prevent direct radiation from the heater falling on the specimens. The specimens are so suspended that there is at least a space of 25 mm between the adjacent specimens, and not less than 50 mm between them and the sides, top and bottom of the inner casing (or baffles). The specimens shall be heated at a temperature of 150 $\pm$ 3°C for 24 hours and then subjected to the controlled atmosphere described in Appendix C for 18 to 24 hours. The bursting strength is determined in the controlled atmosphere or as soon as possible after removal from it and in any case within three minutes of removal.

B-3. DETERMINATION OF BURSTING STRENGTH

B-3.1 Method — The method consists of measuring the pressure required to burst a disk of paper which is gripped firmly round its periphery, and to one side of which pressure is applied at a uniform rate, using liquid as a medium, a flexible impervious membrane being interposed between paper and medium.

B-3.2 Apparatus — The method is based on the use of machines of the Mullen type, in which the specimen of paper is clamped firmly and evenly between two ring clamps so as to encircle a disk of 30·5 $\pm$ 0·01 mm diameter.

The flexible membrane (usually made of soft rubber) is sited immediately beneath the paper and is sufficiently thin and flexible not to affect materially the bursting pressure. The pressure gauge, calibrated to indicate N/m^2 and fractions thereof has an accuracy of ± 1 percent. The calibration range of the gauge is such that the test readings fall between 15 and 85 percent of the scale.

B-3.3 Testing of Specimens

B-3.3.1 The specimen is inserted between the clamps of the machine, which are then carefully tightened so as to grip the paper firmly, and the gauge pointer is adjusted to zero.

The pressure is applied smoothly by operation of the control mechanism at the rate specified for the machine.

When the specimen bursts, the pressure control handle is returned to its original position, the clamps are released and the indicated bursting pressure in kilogram per square centimetre is recorded.

B-3.3.2 Ten tests are made on each set of specimens, five with one side of the paper uppermost and five with the other side uppermost. If in any set of 10 tests one result differs by more than 20 percent from the arithmetic mean of the ten, it is recorded, but not used to calculate the bursting strength.

B-3.3.2.1 If the differing results are more than one, four further specimens of that set are tested (two with one face uppermost and two with the other). The arithmetic mean of the 10 results or, if one has been discarded, of the 9 remaining results; or if 14 specimens have been tested, of the 12 results, showing least divergence from the mean, are deemed to be the bursting strength of that set of specimens.

NOTE — Slipping of test specimens in the clamps, because of insufficient or uneven pressure between them, can be recognized by the appearance of creases in the burst specimen. Any such test is disregarded.

B-3.4 Reporting of Results — The results are reported as follows:

a) The bursting strength in N/m^2 before and after heat-ageing treatment, and

b) The results of any tests which because of excessive variation were not included in the final calculation of bursting strength.

APPENDIX C

(*Clauses* B-1.3 *and* B-2.1)

CONDITIONING OF PAPER SPECIMENS FOR TEST

C-1. CONDITIONING

C-1.1 Single sheets of paper shall be conditioned in a controlled atmosphere for 18 to 24 hours. The controlled atmosphere shall have a relative humidity of 65 ± 2 percent and a temperature of $27 \pm 2°C$. Every specimen shall be tested in the controlled atmosphere or as soon as possible after removal from it and in any case within three minutes.

C-1.2 Where a test room having a controlled atmosphere is not available, a relative humidity of 65 ± 2 percent may be obtained conveniently in an enclosed chamber in which a saturated solution of a mixture of sodium chloride (NaCl) and sodium nitrate ($NaNO_3$) is exposed to the atmosphere in the chamber at the required temperature of $27 \pm 2°C$. The saturated solution shall be prepared by boiling in water a mixture of one part by weight of sodium chloride and two and a quarter parts by weight of sodium nitrate. The solution shall be then cooled and more of the solid mixture is added than can be taken into solution.

C-1.3 The saturated solution should be exposed so that the maximum surface is in contact with the air in the chamber, for example, by covering the floor of the chamber with a tray containing the saturated solution. There should be an excess of solid salt in the liquid to ensure that the solution remains saturated. It is important that the solid should remain covered by the solution and that the surface of the liquid should be free from any crust or film of grease, dirt, etc.

C-1.4 To ensure uniform conditions throughout the chamber, a fan should circulate air over the surface of the saturated solution and around the specimens. Care should be taken to allow free access of the conditioning atmosphere to all the specimens.

APPENDIX D

(*Clause* 5.6)

DETERMINATION OF CONDUCTIVITY OF WATER EXTRACT

D-1. APPARATUS

D-1.1 The apparatus for measurement of conductivity shall comprise a suitable conductivity cell in conjunction with a bridge circuit supplied with current at a frequency of 500 to 3 000 Hz.

D-2. PREPARATION OF EXTRACT

D-2.1 The distilled water used throughout this test shall have a conductivity not greater than 2 microsiemens per centimetre. A blank test shall be carried out before each extraction and if the resultant conductivity exceeds 2 microsiemens per centimetre the test shall be repeated with the same extraction vessel. If the second result also exceeds 2 microsiemens per centimetre the vessel shall be discarded.

D-2.2 To prepare the extract, cut the paper into strips about 20 × 3 mm and put a weight of paper in the ratio of 1 g of the strips to 100 ml of distilled water, into a 250-ml round-bottomed borosilicate glass (high grade resistance glass) or quartz flask fitted with a reflux condenser of either the same quality glass or quartz. The apparatus shall have interchangeable conical ground glass joints. Boil the water gently for 10 minutes, care being taken not to char the paper.

D-3. METHOD OF MEASUREMENT

D-3.1 Determine the cell constant K, if not known, by means of a solution of known conductivity, prepared by dissolving 0·074 6 g of dry potassium chloride in distilled water and diluting the solution to 1 000 ml at a temperature of 27 ± 1°C. Thoroughly rinse out the cell with the solution and fill. The temperature shall be adjusted to 27 ± 1°C and maintained at that value for 15 minutes before as well as during the measurement of resistance.

D-3.2 Carry out the test of water extract as described above, as soon as practicable after the preparation of the extract.

D-4. CALCULATION

D-4.1 The cell constant $K = R \times (147{\cdot}4 + C)$

$$\text{Conductivity of water extract in micromhos per centimetre} = \frac{K}{R_1} - C_1$$

where

R = measured resistance of potassium chloride solution in megohms,

C = conductivity of distilled water in micromhos per centimetre,

R_1 = measured resistance of the water extract in megohms, and

C_1 = conductivity of the blank in micromhos per centimetre.

NOTE — For most purposes, where it is not convenient to test the water extract at 27 ± 1°C, it is sufficiently accurate to apply the following correction:

$$\text{Conductivity at } 27°C = \frac{X}{1 \pm 0{\cdot}02\,t}$$

where X is the conductivity obtained when measurement is made at t°C above or below 27°C; $0{\cdot}02\,t$ being added when measurement is made above 27°C and subtracted when made below 27°C.

APPENDIX E

(*Clause* 5.7)

DETERMINATION OF OIL ABSORPTION

E-1. GENERAL

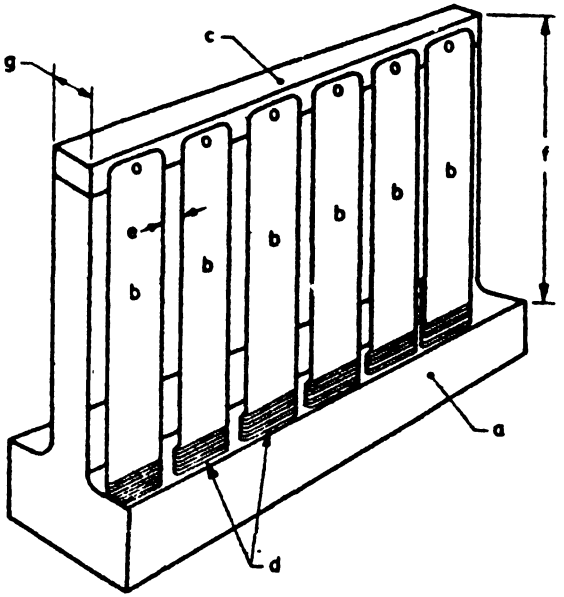
E-1.1 The absorption of oil by the paper is determined in the machine (longitudinal) direction, and in the cross (transverse) direction.

E-2. PREPARATION OF SAMPLES

E-2.1 The oil absorption test is carried out on 6 strips of paper 200 mm long and 50 mm wide of which 3 strips are cut in the machine direction and 3 in the cross direction of the paper. The strips are cut in pairs, one pair from each edge and one pair from the centre of the roll or sheet. A line is marked across each specimen exactly 12·5 mm from the lower end.

E-3. METHODS OF TEST

E-3.1 All the specimens are pinned vertically to the suspension bar, which is fixed above a suitable tank as shown in Fig. 2, so that the top end of each specimen is level with the top of the bar. Small lead clips are attached to the lower ends of the specimens to serve as weights.



All dimensions in millimetres.

a 400 × 75 × 45

b 200 × 50

c 400 × 20 × 20

d 50 × 6·5 × 1·5

e 13 *Min*, spacing

f 180

g 20

FIG. 2 APPARATUS FOR OIL ABSORPTION TEST

E-3.2 The apparatus with the specimens attached is placed in an oven with a quantity of insulating oil complying with relevant Indian Standard in a separate vessel. The temperature of the oven is between 95°C and 100°C. The apparatus and oil are allowed to remain in the oven for not less than one hour and sufficient oil is then transferred carefully to the tank by means of a funnel so that the surface of the oil is coincident with the lines marked on the specimens. The apparatus is maintained at a temperature between 95°C and 100°C for 2 hours. The height to which the oil rises in each specimen after 2 hours is noted.

APPENDIX F

(*Clause* 10.1)

SAMPLING OF PAPER-COVERED ROUND ALUMINIUM CONDUCTORS

F-1. SCALE OF SAMPLING

F-1.1 Lot — In a consignment, all the drums of paper covered round

aluminium conductors of the same grade and size manufactured from the same material in the same factory under similar conditions of production shall be grouped together to constitute a lot.

F-1.2 The number of drums to be selected from each lot shall depend upon the size of the lot and shall be in accordance with col 1 and 2 of Table 6.

TABLE 6 SAMPLE SIZE AND ACCEPTANCE NUMBER

(*Clauses* F-1.2 *and* F-2.1)

LOT SIZE	SAMPLE SIZE	ACCEPTANCE NUMBER
(1)	(2)	(3)
Up to 50	8	0
51 ,, 100	13	0
101 ,, 300	20	1
301 ,, 500	32	2
501 and above	50	3

F-1.2.1 These drums shall be selected from the lot at random. In order to ensure the randomness of selection, procedure given in IS : 4905-1968* may be followed.

F-2. NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

F-2.1 From each of the drums selected at random according to col 1 and 2 of Table 6, suitable lengths of test samples shall be taken after discarding approximately 1·5 metre of the wire. The number of tests to be carried out for each of the acceptance tests shall be in accordance with col 1 and 2 of Table 6. For this purpose suitable number of test samples shall be taken from each of the selected drums and subjected to the tests. A sample failing to satisfy any of the acceptance tests shall be considered as defective. The lot shall be considered as conforming to the requirements of acceptance tests if the number of defectives found in the sample is less than or equal to the corresponding acceptance number given in col 3 of Table 6, otherwise the lot shall be rejected.'

*Methods for random sampling.

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